

Gas Well Drilling and Development Marcellus Shale



June 12, 2008 Commission Meeting
Elmira, New York

Marcellus Shale - Why Now?

- For many years it has been known that natural gas exists in the Marcellus Shale
- Advances in horizontal drilling, hydraulic fracturing, and higher natural gas prices in recent years have made shale gas wells more profitable
- The success of the Barnett Shale in Texas has spurred the search for other sources of shale gas across the United States
- Estimates of recoverable natural gas reserves from the Marcellus Shale range from 50 - 200 trillion cubic feet (TCF)

Marcellus Shale Geology

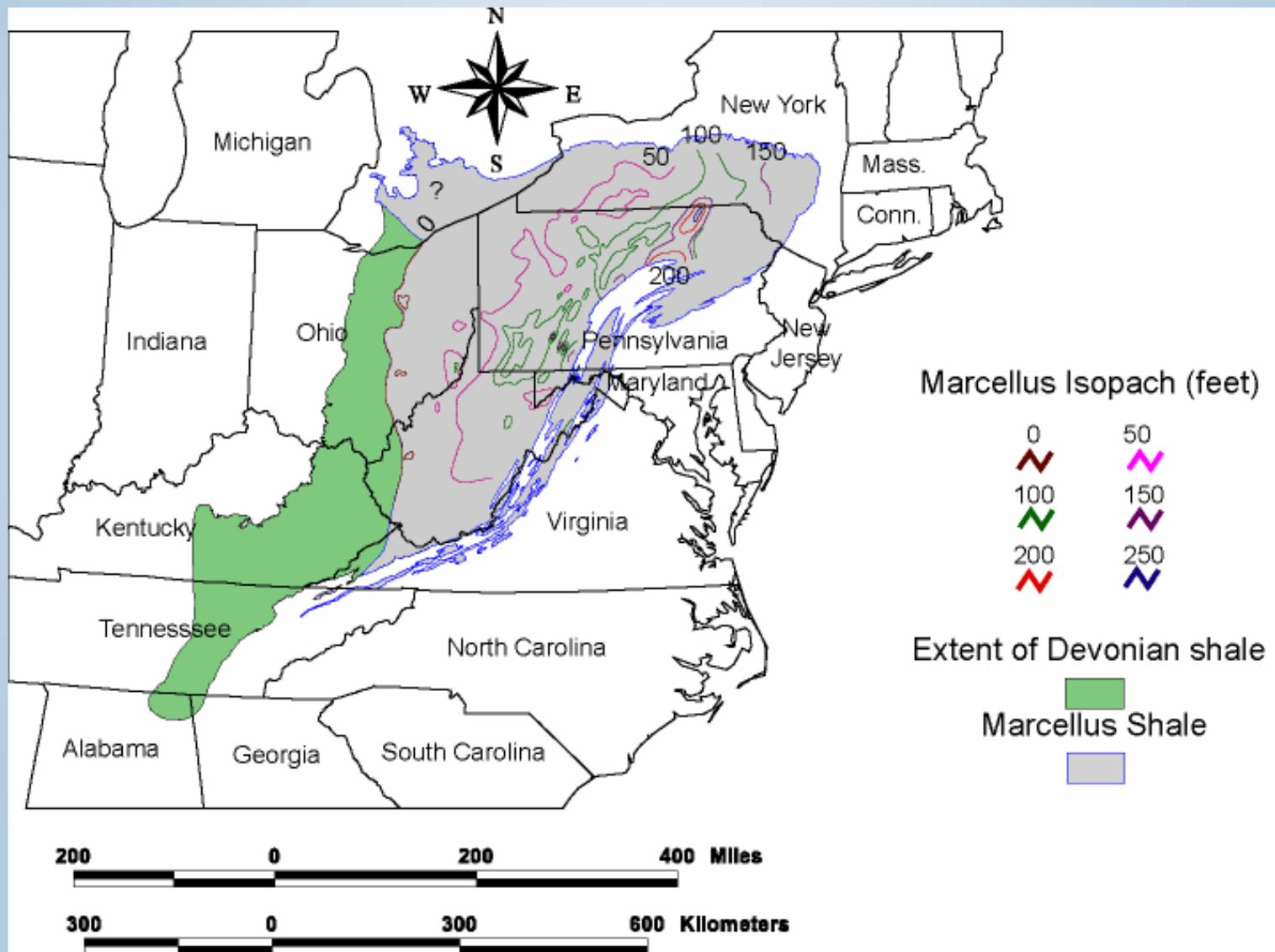
- Devonian Black Shale
 - Low density fissile shale
 - Carbonaceous (organic rich)
 - Vertical natural fractures
 - Low permeability
 - Slightly radioactive

Geographic Location

- Appalachian Basin Province
 - NY to PA, OH, MD, WV and VA
 - Trending northeast, spans a distance of approximately 600 linear miles, and 54,000 square miles
 - 72 percent of the Susquehanna River Basin is underlain by the Marcellus Shale

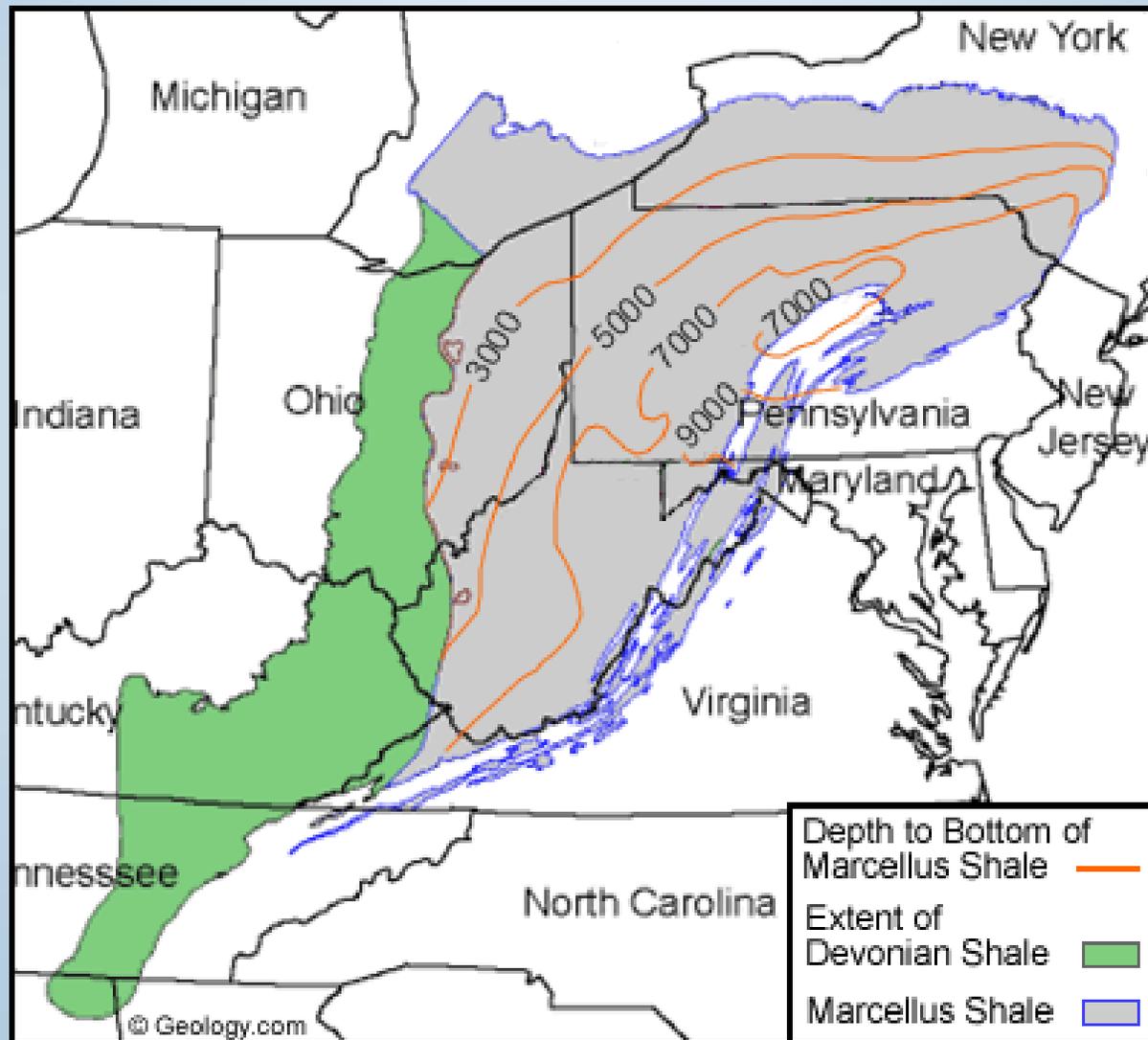


Thickness Map of the Marcellus Shale



Map from the United States Geological Survey (USGS), Open-File Report 2006-1237, Milici and Swezey.

Map of the Approximate Depth to the Base of the Marcellus Shale



Map retrieved from: geology.com/articles/marcellus-shale.

Marcellus Shale Gas

- Large volume of entrapped natural gas approximately 5,000 - 8,000 feet below ground surface
- Regional stratigraphic (blanket-like) accumulations stored in a tight formation
- Requires “unconventional” means for extraction
 - Horizontal Drilling
 - Fracture Stimulation (Hydrofrac)

Horizontal Gas Well Drilling

- Drill vertically to desired depth in the formation
- Drill rods are then turned (horizontal) in order to drill perpendicular to naturally occurring vertical fractures

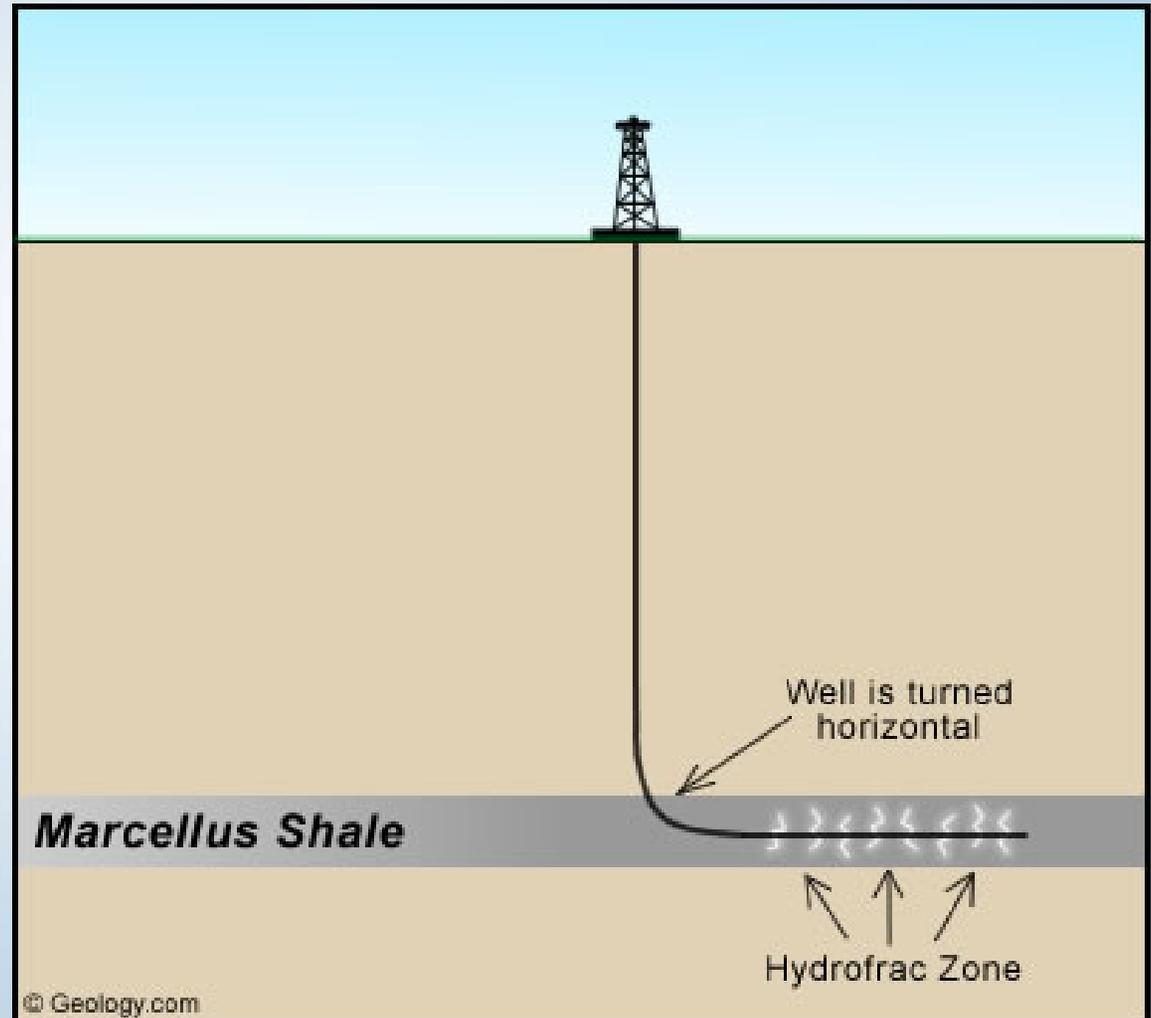


Illustration retrieved from: geology.com/articles/marcellus-shale.

Vertical vs. Horizontal Drilling

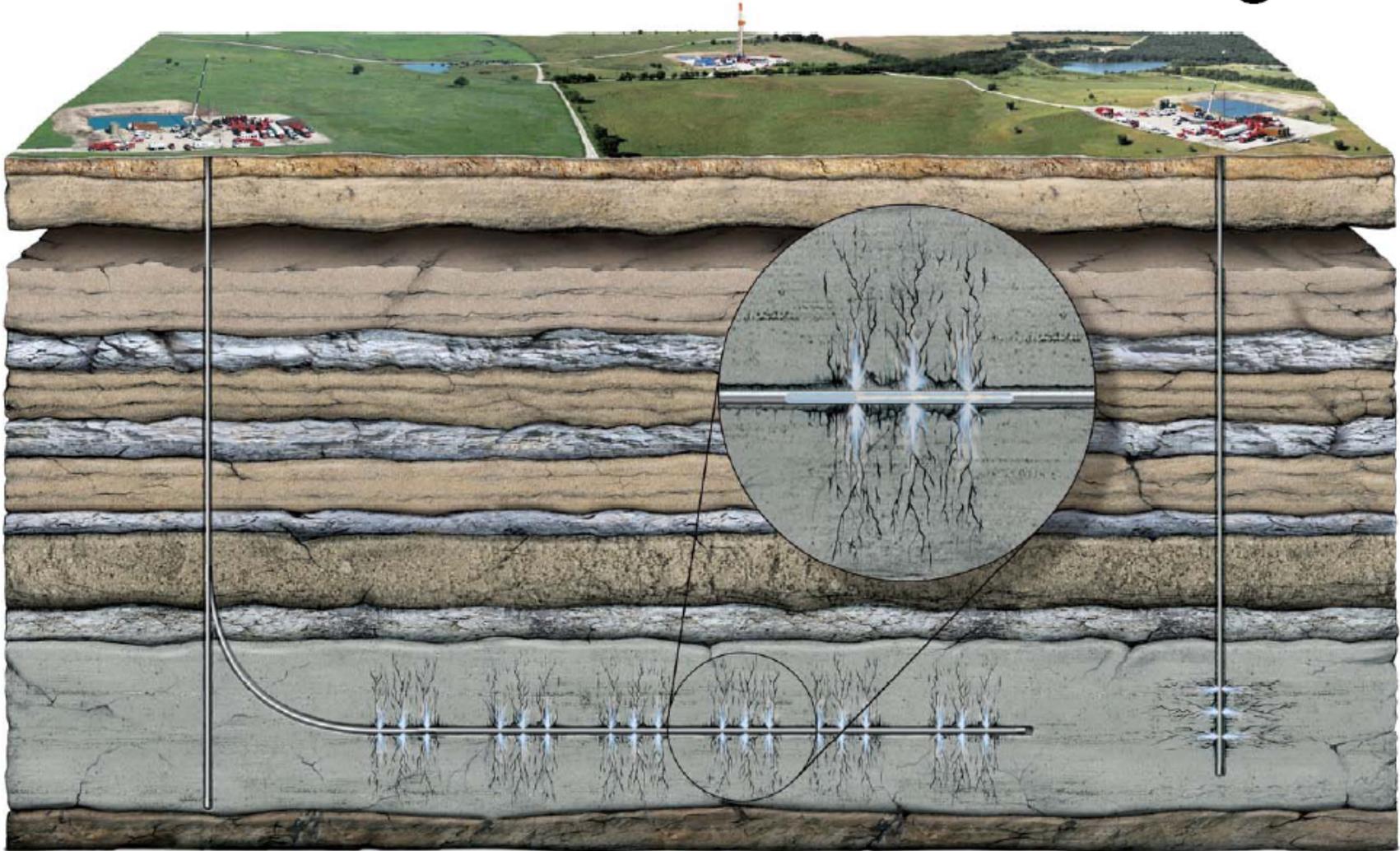


Illustration retrieved from: Independent Oil and Gas Association of Pennsylvania's *Drilling & Developing the Marcellus Shale*

Horizontal Drilling

- Can provide greater access with a smaller footprint
- Multiple horizontal wells from a single drilling pad could drain 200 - 400 acres

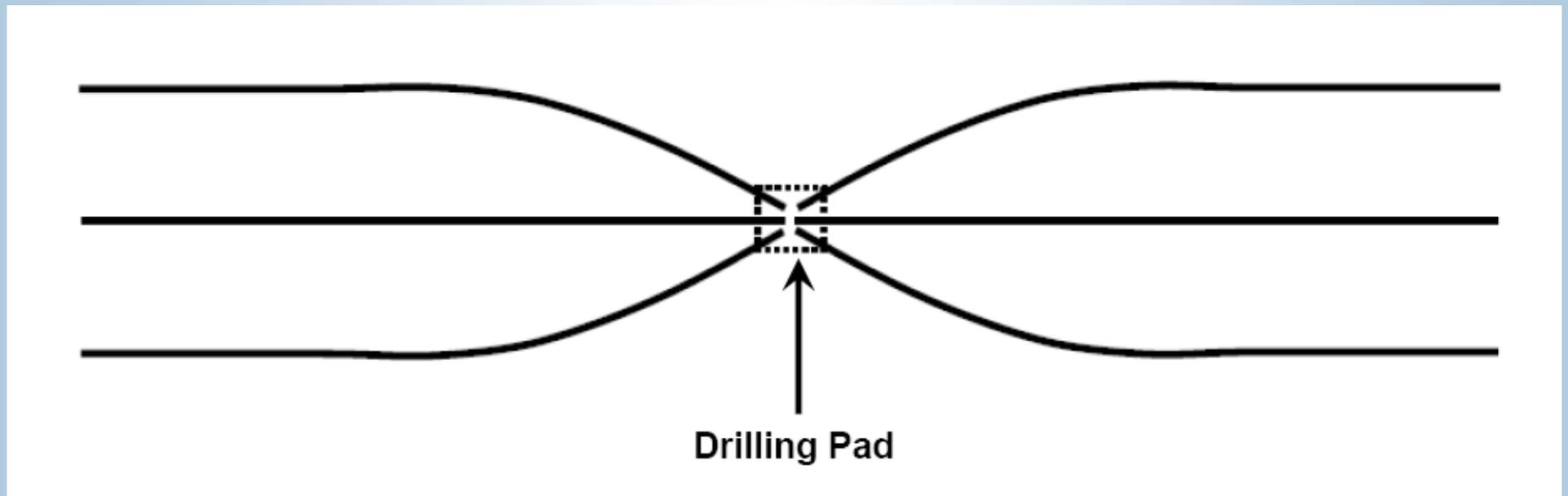


Illustration retrieved from: Independent Oil and Gas Association of Pennsylvania's *Drilling & Developing the Marcellus Shale*

Fracture Stimulation (frac or hydrofrac)

- Increases the permeability of the shale
- Increases the rate which gas can be produced and recovered from the reservoir formation

Hydraulic Fracturing (Hydrofracing)

- Force a fracturing fluid (primarily water) into a sealed off portion of the borehole under high pressure
- The applied pressure causes the formation to fracture, allowing the fracturing fluid to enter further into the formation and extending the cracks
- Solid proppant (usually sand) is added to the fracture fluid to keep fractures open after the injection stops

Hydrofracing (cont'd)

- Hydrofracing typically requires millions of gallons of water
- Flowback water requires off-site treatment
 - Brine
 - Hydrocarbons
 - Metals
 - May be slightly radioactive

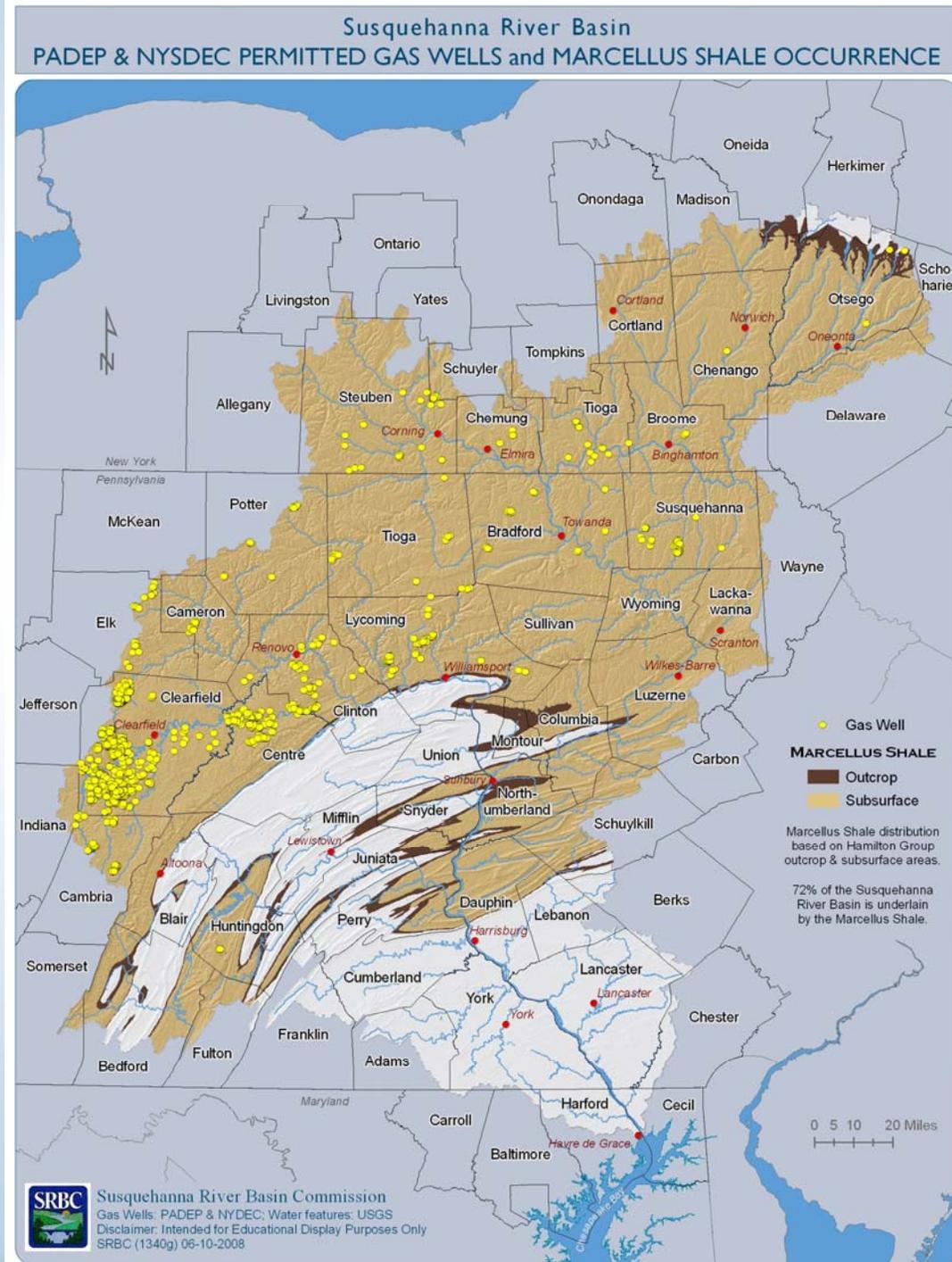
Commission Regulation

- Consumptive water use definition (§806.3)
 - The loss of water transferred through a manmade conveyance system or any integral part thereof (including such water that is purveyed through a public water supply system), due to transpiration by vegetation, incorporation into products during their manufacture, evaporation, *injection of water or wastewater into a subsurface formation from which it would not reasonably be available for future use in the basin*, diversion from the basin, or other process by which the water is not returned to the waters of the basin undiminished in quantity.

Commission Regulation (cont'd)

- Projects requiring review and approval
 - Consumptive water use §806.4(a)(1)
 - 20,000 gpd/30-day average (600,000 gallons)
 - Water withdrawals §806.4(a)(2)(iii)
 - 100,000 gpd/30-day average (3,000,000 gallons)
 - Any project which involves a withdrawal from a groundwater or surface water source and which is subject to the requirements of §806.4(a)(1) regarding consumptive use.

Location of PADEP and NYSDEC Permitted Gas Wells in the Susquehanna River Basin



Typical Gas Well Site



Image retrieved from: Independent Oil and Gas Association of Pennsylvania's, Drilling & Developing the Marcellus Shale

Frac tanks are typically used to store water on-site for drilling and hydrofracing



Brine Treatment Facilities

- The fracturing process uses an average of 2 to 9 million gallons of fresh water per well
- Currently no brine treatment facilities operate within the basin

Potential Impacts/Approval Challenges

- Consumptive Use/Surface Water Withdrawal
 - Sites are located in headwater areas
 - Streams are typically high quality
 - Operations continue during low flow periods
 - Passby considerations/streams encroachment
 - Cumulative impacts of multiple projects
- Potential Local Infrastructure Issues
 - Increased traffic
 - Dust control

Recent Commission Actions

May 30, 2008 - Cease and desist Orders were issued to two gas well drilling companies

June 6, 2008 - Letter to 23 gas well companies operating within the Susquehanna River Basin clarifying that water used for developing natural gas wells in the Susquehanna River Basin needs Commission approval

Moving Forward

- Gas well site inspections are currently ongoing
- Numerous additional gas well drilling companies will be notified
- Notice of Intent for Approval by Rule
 - Pursuant to 18 CFR Section 806.22(e)
- Staff is expecting applications for consumptive use and surface water withdrawal

References

- Barrett, Ramsay. "The Depositional Setting of The Marcellus Black Shale". Appalachian Producers Issues Seminar. Independent Oil and Gas Association of West Virginia. Retrieved on 2008-06-10. <www.iogawv.com/RamsayBarrett-Shale.pdf>.
- Durham, Louise S. "Appalachian Basin's Marcellus – the new target: Another Shale Making Seismic Waves." AAPG Explorer. American Association of Petroleum Geologists. March 2003.
- Harden, R. W., et all. "Northern Trinity/Woodbine Aquifer Groundwater Availability Model, Assessment of Groundwater Use in the Northern Trinity Aquifer Due to Urban Growth and Barnett Shale Development", TWDB Contract Number: 0604830613, January 2007
- Independent Oil and Gas Association of Pennsylvania. "Drilling & Developing the Marcellus Shale." Pennsylvania State Association of Township Supervisors Annual Meeting, Retrieved on 2008-06-10. <naturalgaslease.pbwiki.com/f/Gas+Assoc+Presentation+at+PSATS+May+2008.pdf>.
- Milici, Robert C.; Swezey, Christopher S. (2006). Assessment of Appalachian Basin Oil and Gas Resources: Devonian Shale– Middle and Upper Paleozoic Total Petroleum System. Open-File Report Series 2006-1237. United States Geological Survey.
- "Marcellus Shale – Appalachian Basin Natural Gas Play." geology.com. Retrieved on 2008-06-10. <geology.com/articles/marcellus-shale>.
- NYSDEC, 1999. New York State Department of Environmental Conservation, Division of Solid & Hazardous Materials. "An Investigation of Naturally Occurring Radioactive Materials (NORM) in Oil and Gas Wells in New York State." April 1999.
- "The Marcellus Shale – America's next super giant." Retrieved on 2008-06-10. <catskillmountainkeeper.org/node/290>.

Gas Well Drilling and Development Marcellus Shale

Michael Brownell
Chief, Water Resources Management
Telephone: (717) 238-0423
E-mail: mbrownell@srbc.net



Presented at the June 12, 2008 Commission Meeting